Analysis of Trade-offs from the use of Hydrogen Blended with Natural Gas in the European Union

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Context

Increasing use of hydrogen (H_2) across the economy is currently seen as an important strategy for decarbonizing fossil fuel-dependent sectors. However, the combustion of hydrogen leads to higher formation of nitrogen oxides (NOx), when compared to natural gas. While potential increase in NOx could drive formation of ozone (air pollutant and potent greenhouse gas), fugitive losses of H_2 will also indirectly contribute to global warming, due to interaction with other gases in the atmosphere. This study will improve understanding of impacts the hydrogen economy might have on air pollution and GHG emissions. The results will be shared with the atmospheric and climate modelling community and eventually help to close an important knowledge gap supporting also informed policy making.

Objectives

This study seeks:

- To quantify and evaluate the potential NOx increases in the European Union (EU27) countries due to the combustion of hydrogen blended with natural gas.
- To estimate potential fugitive emissions of hydrogen under net-zero scenarios and future hydrogen economies.

Methods

We use the Greenhouse Gas and Air Pollution Interactions and Synergies (GAINS) model framework to estimate NOx emissions from hydrogen combustion and H_2 fugitive emissions in the European Union (Amman et al, 2011).

The hydrogen extension (see below) to the GAINS framework considers the all steps of its supply-chain. We assume that fugitive emissions are possible at production, transmission, storage and distribution phases. Final uses of hydrogen involve combustion, fuel cells and feedstock. Emission factors are attributed according to the sector and control measures. E.g. shift of pipeline materials to plastics or using selective catalytic reduction in boilers. H_2 can be carried in liquid, compressed or adsorbed form.

This extension to the GAINS framework will be achieved by retaining its overall consistency and integrity, ensuring that various synergistic effects as well as the consideration of impacts on air pollution and global warming.

Impacts of Hydrogen

Since hydrogen became a viable alternative for the transition to a low carbon economy, literature has turned its attention to its possible impacts:

1. **Production methods:** H_2 climate impact is directly related to technologies and controls used – electrolysis, gasification, steam methane reforming, and deployment of CCS.
2. **Fugitive emissions:** current studies have been estimated hydrogen's GWP-100 to be about 6-18 and GWP-20 to 16-64 (Sand et al., 2023). Emission rates are still uncertain though.
3. **Combustion emissions:** NOx emissions from hydrogen blends vary according to the burner type, load, H_2-CH_4 blending ratio and premixing. Figure 1 presents overall NOx variation in comparison to natural gas. Different sectors or appliances might present alternative variations.

For impacts listed here, existing control strategies can be applied, which is already employed according to EU regulations.

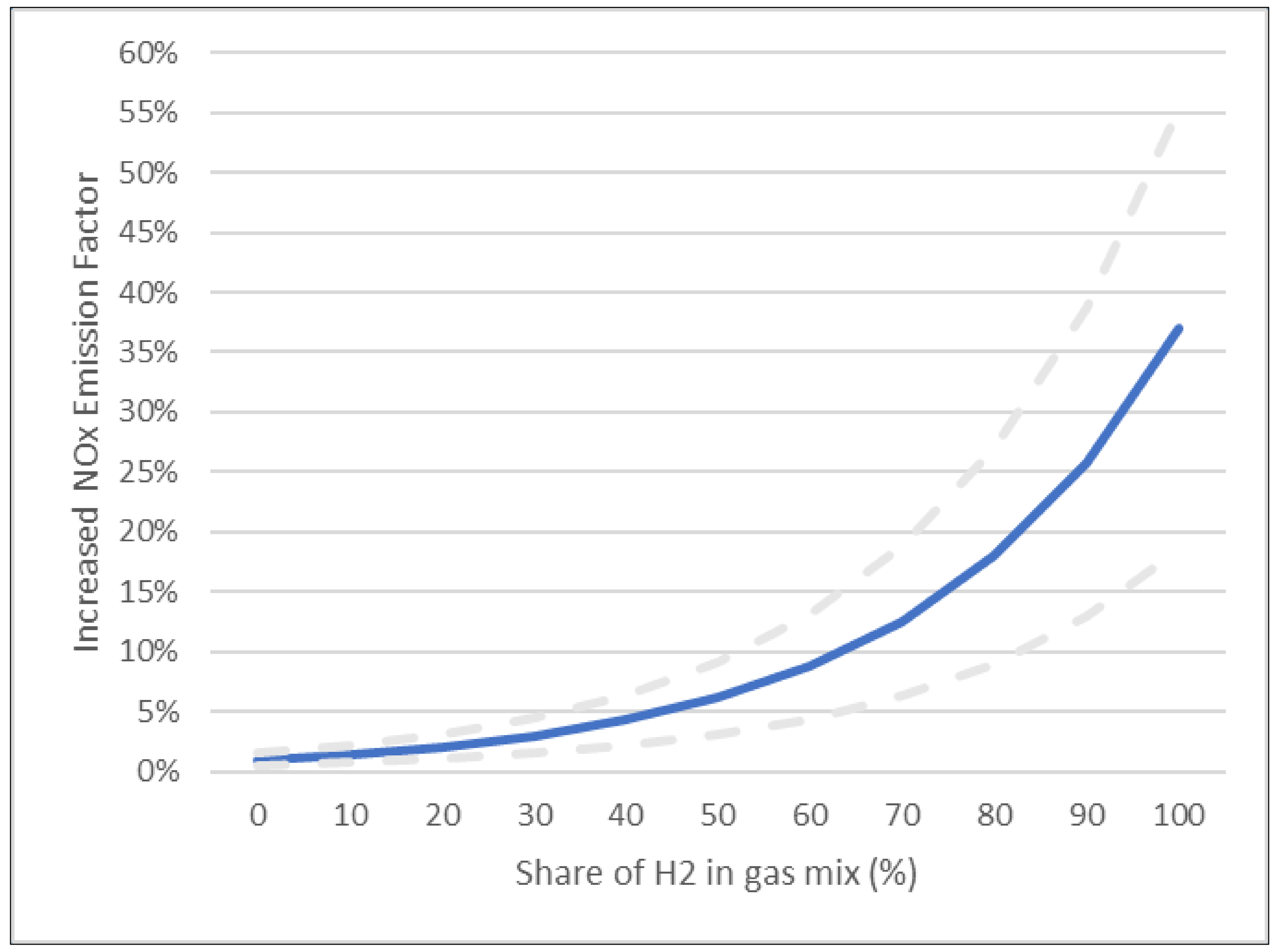
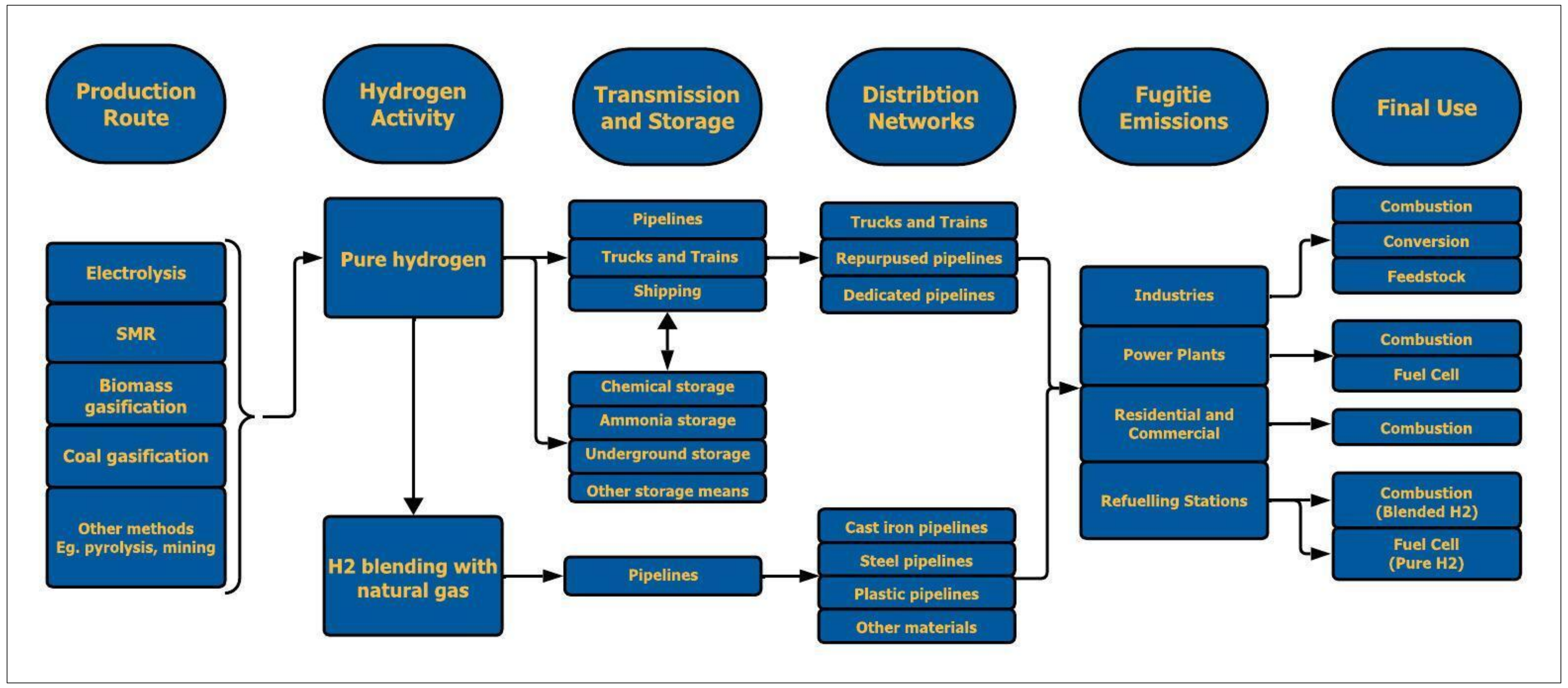


Figure 1: NOx emission factor variation, in relation to methane, based on hydrogen blending ratio.

Source: based on (Douglas et al., 2022)

Hydrogen Structure in GAINS



Expected Results

While the paper asserts that the findings are unlikely to influence the development or viability of future hydrogen economies in Europe, it acknowledges the importance of the analysis in revealing potential emissions trends and identifying local or country-specific trade-offs.

The emphasis on existing regulations and emission control strategies in Europe provides context for the limited air quality impacts expected from the overall trajectory of hydrogen adoption.

Moreover, these results could lead to relevant insights regarding expected H_2 fugitive emissions which may impact climate mitigation targets and economical viability.

Development work will be continued and applied globally within the **HyWAY** project funded by the EU Horizon. Scientists from different fields will cooperate to understand leakage rates, atmospheric interactions and scenarios modeling for future H_2 economy.

Join GAINS community!

References

Amann, M., Bertok, I., Borken-Kleefeld, J., Cofala, J., Heyes, C., Höglund-Isaksson, L., Klimont, Z., Nguyen, B., Posch, M., Rafaj, P., Sandler, R., Schöpp, W., Wagner, F., & Winiwarter, W. (2011). Cost-effective control of air quality and greenhouse gases in Europe: Modeling and policy applications. *Environmental Modelling and Software*, *26*(12), 1489–1501.

Douglas, C., Emerson, B., Lieuwen, T., Martz, T., & Steele, R. (2022). *NO x Emissions from Hydrogen-Methane Fuel Blends*.

Sand, M., Skeie, R. B., Sandstad, M., Krishnan, S., Myhre, G., Bryant, H., Derwent, R., Hauglustaine, D., Paulot, F., Prather, M., & Stevenson, D. (2023). A multi-model assessment of the Global Warming Potential of hydrogen. *Communications Earth and Environment*, *4*(1). https://doi.org/10.1038/s43247-023-00857-8